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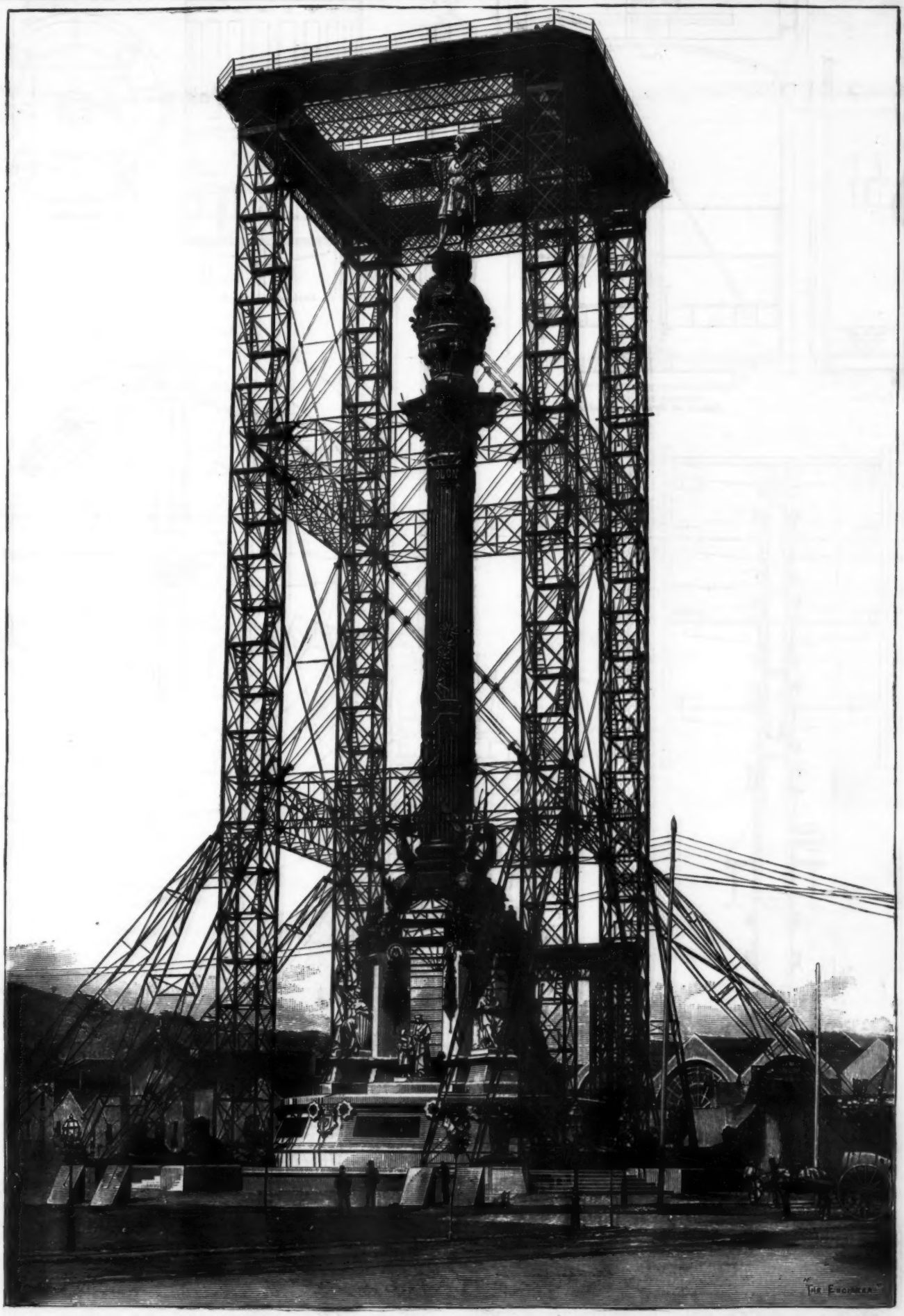
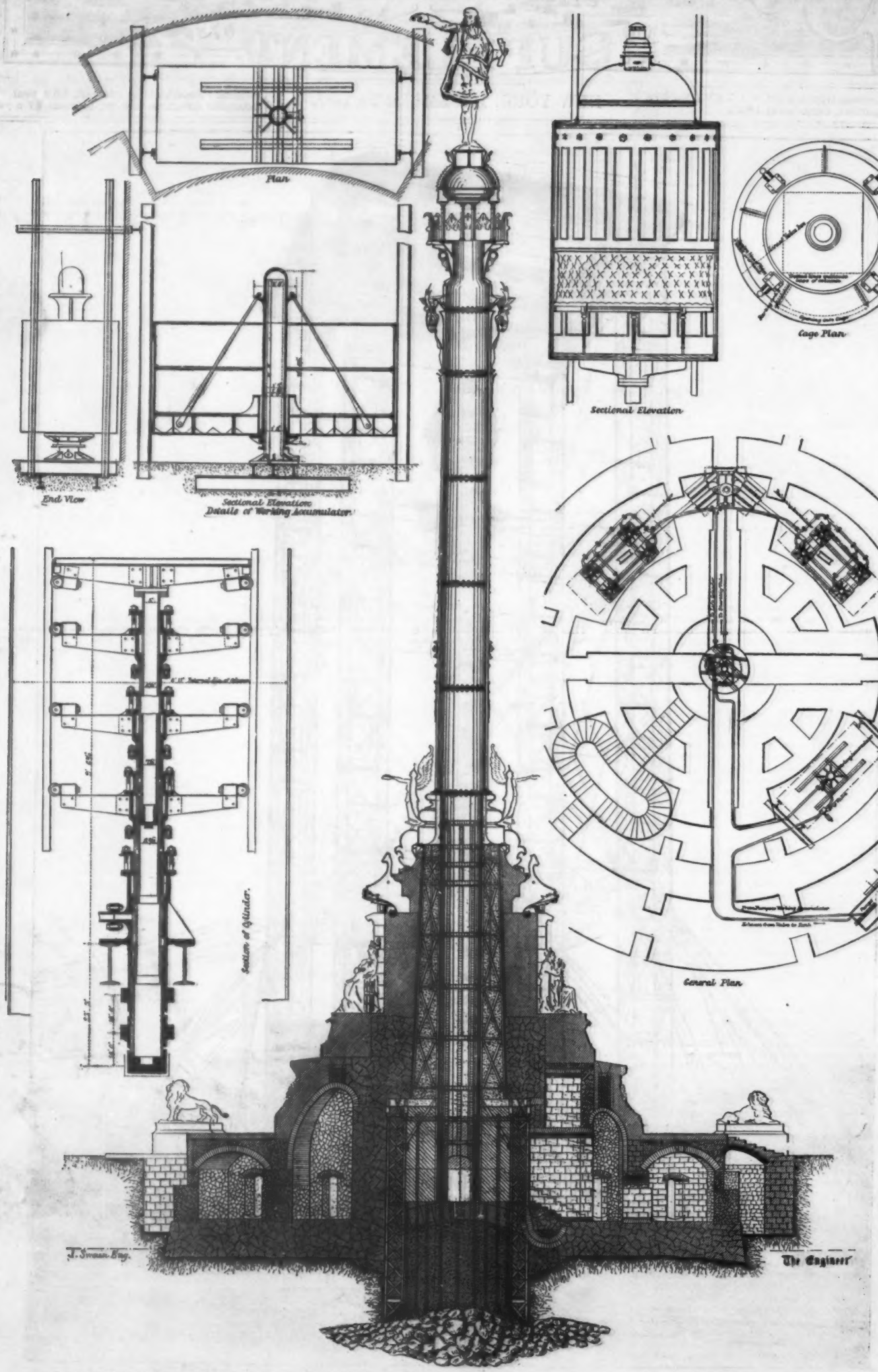


MONUMENT TO COLUMBUS, AT BARCELONA, SHOWING THE ERECTING STAGING.

MONUMENT TO COLUMBUS, AT BARCELONA.

ON the 31st of May last a large monument at Barcelona, in commemoration of Christopher Columbus, was inaugurated by the Queen of Spain. In our SUPPLEMENT, number 674, we gave a page engraving of the completed work. We now give, from *The Engineer*, an engraving of the monument, from a photograph taken before the removal of the novel staging. The foundation and lower parts of the structure are of stone; the upper portion or column is made of cast iron cylinders bolted together with internal flanges. The statue of Columbus on the top is solid bronze, and weighs nearly fourteen tons. In the interior of the column a hydraulic lift has been fitted by Messrs. Joseph Richmond & Co., London. The lift has a total travel of 184 feet, and is constructed on their hydraulic balanced and compensating principle, the motive power employed being a six horse power Otto gas engine.

It will no doubt interest our readers to know the general conditions under which this lift was erected. The stipulated requirements of the Corporation of Barcelona as regards this lift required considerable

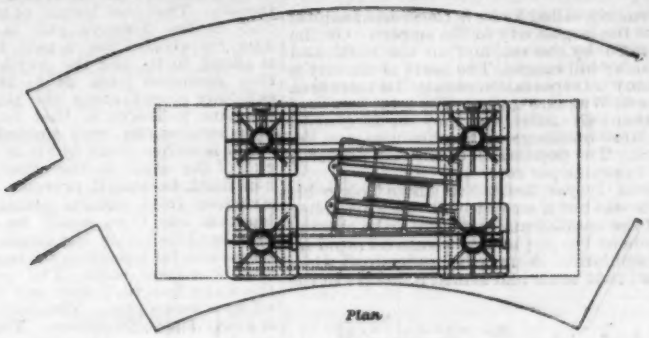


THE HYDRAULIC ELEVATOR OF THE MONUMENT TO COLUMBUS, AT BARCELONA.

attention on the part of the constructors, as several important features had to be observed besides the all-important one of cost. The principal requirements were as follows: "The lift to be on the direct-acting hydraulic principle, and arranged so that the ram is always in compression. No overhead balance gear will be entertained. The total travel between landings, 134 feet. The load will consist of six passengers. The whole of the mechanism employed to be arranged inside the vaults under the base of the column. The lift to be set up in working order within six months of date of order, under penalty." Messrs. Richmond & Co. at once condemned the idea of a direct-acting ram all in one piece, as it would have necessitated boring a well some 140 feet deep; and taking into consideration that the monument was erected on a hard quartz rock, and that the sea level was only 12 feet below the surface, the necessity of boring could not have been carried out in the stipulated time. The plan decided upon was to make the lift ram in four telescopic sections, the advantage of which is at once apparent. A well only one-quarter of the depth would be requisite, and each section of the ram would have a crosshead on its upper end fitting between the guides fixed to the column. The ram would thus be supported at four equidistant points in its length when fully extended, and therefore great stability would be attained and vibration greatly reduced.

Next came the difficulty of arranging a hydraulic balance in the vaults, the largest of which were 18 feet by 8 feet by 18 feet high. These dimensions only admit of an 8 foot stroke to the balance. The arrangement shown on the accompanying drawings was eventually arrived at and passed. It will be noticed on reference to the drawings that the balancing accumulators are in two groups of four each. The capacity of these eight cylinders is slightly in excess of the capacity of the lift cylinder. The fluid contained in the lift cylinder simply circulates to and fro, between it and the balancing accumulators, as the lift travels up and down. These accumulators are loaded so as to just counterbalance the weight of the lift, ram, and cage. The rams of the balancing accumulators are coupled to another ram and cylinder, called the compensator, by means of strong chains, the breaking strain of which is seventy-two tons each. The compensator is actuated by pressure from a storage accumulator, and acts as follows: On reference to the drawings it will be seen that the chains coupled to the rams of balancing accumulators are attached to spiral drums or cams on the compensator. Side by side, on the same spindles with these drums, are two other drums, which have two concentric peripheries. These drums are coupled by chains to a crosshead on the compensator ram. When pressure is applied to the ram of the compensator, it will pull on the chains coupled to the rams of the balancing accumulators and pull the same down with a gradually increasing force owing to the increasing leverage obtained by the spiral drums. This increasing power will necessarily cause a gradually increasing pressure per square inch in the lift cylinder, and thus compensate for the loss due to the varying immersion of the ram in the lift cylinder, which in this instance amounts to a difference of 50 lb. per square inch, as measured by a gauge. The pressure in the lift cylinder at starting is 125 lb. per square inch, and when at the top 175 lb. per square inch. The actual amount of water required for each stroke of the lift is that displaced by the compensator ram only. The storage accumulator is loaded to a pressure of 550 lb. per square inch, and this drives the lift at 80 feet to 100 feet per minute, according to the number of passengers in it. In the event of any of the chains breaking, a self-acting brake valve is provided between the lift and the balancing accumulators, so that the lift could not descend at an accelerated speed.

Perfect compensation for the varying immersion of the ram in the lift cylinder is obtained by this arrangement, as in the whole travel of 134 feet a perfectly uniform speed is attained throughout—a substantial feature—as hydraulic lifts in general invariably move more slowly as they reach the top level, even in heights of 60 to 70 feet. The compensating balance is covered by the 1887 patent of Mr. C. F. Archer, by whom the whole of the machinery has been designed and arranged. This is, we believe, the first instance of a telescopic lift fitted with a hydraulic compensating balance. This lift was included in the exhibits at the Barcelona Exhibition, and has been awarded a gold medal. The architect of the monument is Signor Don Cayetano Buigas, and that of the scaffold builder, Signor Don Juan Torras.



Details of Balancing Accumulators.

HYDRAULIC BALANCE LIFT, COLUMBUS MONUMENT.

THE NEW INSTITUT PASTEUR.

THE inauguration of the Institut Pasteur took place in Paris, France, on Wednesday, November 14, in the presence of the President of the Republic and a large number of savants and professors, giving to that quarter of the city, which is ordinarily so quiet, a very unusual appearance of activity.

It is this quiet and retired district that Mr. Pasteur has selected for conducting this work. The Institut occupies on the Boulevard Vaugirard, between the street Dutot and the street Des Fourneaux, an area of 12,000 yards. It consists essentially of two buildings connected with one another by a large gallery.

Our picture represents both buildings; one has its facade on the street Dutot and the other on street Des Fourneaux. The facade of the first, in the style of Louis XIII., is of a severe type. On two tablets placed over the entrance are the words, "Souscription publique, 1888," and below it, "Institut Pasteur."

The first story is reached through a large hall. At the right are the private apartments of Mr. Pasteur; a dining room ornamented with a large chimney in carved wood, a salon, and two studies. At the left is the library, lighted with eight windows, and serving the purpose of a consulting room as well. Below in the basement are the private laboratories of Mr. Pasteur, the laboratories of his assistants, and various other chambers. The top story are store rooms and some rooms of the employes.

It may be remarked that, owing to about eight yards difference in the level between the street Dutot and the street Des Fourneaux, the basement of the first building is on a level with the first story of the second. In the latter are the rooms designed for the public as well as the experimental laboratories.

At the right on the first floor are the rooms called "Rabies." They comprise a public waiting room, a room of inoculation and of syncope, where those under the influence of anæsthetics are treated, chamber of records, reserved also for the preparation of vaccine, and a room in which are preserved the skins of animals. The latter is to be kept at an even temperature; it has folding doors and double windows.

At the left are laboratories and an amphitheater for lecturing to the students; a dissection chamber, a zoological room, an aquarium and photographic dark room. The treatment of rabies will be under the direction of Prof. Grancher.

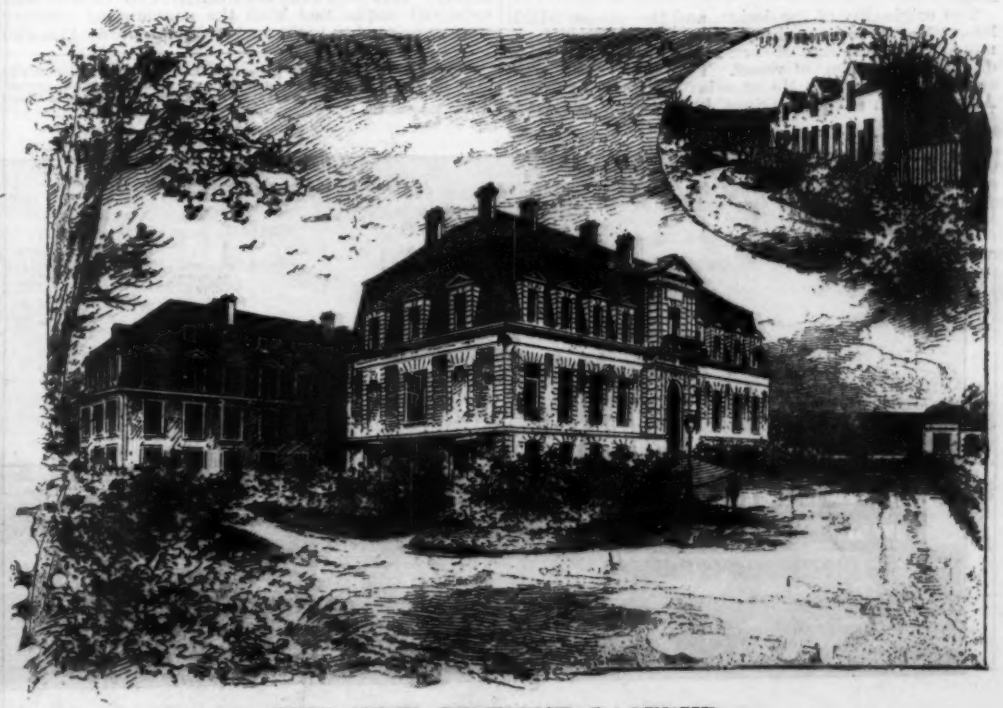
On the second story of the second building may be found the laboratories for the examination of microbes, under the direction of Mr. Roux, and a laboratory of biological chemistry, under the direction of Prof. Duclaux. These laboratories are furnished with cases for the reception of collections, hot rooms and wash rooms, and also a special room where the assistants and the students can work together.

On the third story are the experimental laboratories, divided off as on the second story. Foreign savants will be allowed to take the course and to participate in the work. Laboratories have already been placed at the disposal of two Russian savants, Dr. Gamaleia and Dr. Metchnikoff.

Between the two buildings are a certain number of small houses, most picturesque in appearance, which also belong to the Institut Pasteur. Here may be found a sheepfold, there a dog kennel and further on an aviary; also houses for rabbits, guinea pigs, chickens, etc. There is also a house, two stories in height and surmounted by a clock, where the animals are to be kept that have been subjected to the action of virus. Two little houses, which were built before the land was purchased, have been rebuilt and fitted up as lodgings for the employes. An evergreen hedge surrounds the whole, and a chimney over a hundred feet high rises in the middle, and conducts away the fumes from the boilers, which are located in the basement of the building and which serve to heat the various departments.

It should be borne in mind that the public subscription, by which the Institut has been built, has already reached the enormous sum of two million and a half of francs; of this sum one and a half million was employed in the purchase of the land and in the construction of the buildings.

This monument was built on the plans of Mr. Petit, architect, who died in the month of October, 1887. The work was continued and finished by his colleague, Mr. Brebant.—*L'Illustration.*



THE NEW INSTITUT PASTEUR.

MANUFACTURE OF CHLORINE—WELDON-PECHINEY PROCESS.

THIS process has been worked at Salindres in an experimental plant, designed to produce a ton of chlorine daily. This process consists (1) in dissolving magnesium oxide in hydrochloric acid; (2) making magnesium oxychloride; (3) crushing, breaking, and sifting the oxychloride; (4) drying the oxychloride; (5) decomposing the oxychloride by heated air, magnesium oxide being left to again go through the first operation. The solution of magnesium chloride is evaporated so that it contains not more than six equivalents of water, and

is then converted into oxychloride by mixture with one and a third equivalents of magnesium oxide. The mass becomes very hard and disengages much heat during solidification, although the operation lasts but about twenty minutes. The pieces are crushed into fragments about the size of a walnut, and these are freed from dust by passing through a rotating sieve. The oxychloride is then dried, and introduced into a special apparatus consisting of a series of furnaces having decomposing chambers, heated by a movable regenerative burner. In the first stage of the decomposition there is a rapid evolution of steam which decomposes a part of the oxychloride, forming hydrochloric acid, that passes off with the water vapor. The resulting mixture of anhydrous magnesium chloride and magnesium oxide is decomposed by the oxygen of the air at the high temperature, only magnesium oxide remaining. The products are drawn from the furnace by an aspirator and passed through a hydrochloric acid condensing tower for the retention of the acid at first disengaged—and this is used in the first operation, together with more obtained by the decomposition of salt—while the mixture of air and chlorine passes on and is used for the manufacture of chlorate. —*Jour. Soc. Chem. Ind.*

THE PADDLE STEAMER HONAM.

WE give an illustration of the paddle steamer Honam, a model of which was shown by the builders at the Glasgow exhibition. The vessel, which is remarkable in several respects, was constructed and engined in 1882 by Messrs. A. & J. Inglis, of Pointhouse, Glasgow, for the Hong-Kong, Canton, and Macao Steamboat Company, of Shanghai, for trading on the Canton River.

The length of the Honam is 270 ft.; breadth moulded, 38 ft.; extreme breadth, 72 ft. 6 in.; depth moulded, 13 ft. 3 in.; extreme, 30 ft.; and her tonnage is 2,800 tons. One feature of the ship, it will be seen, is that the sponsing is carried round the ship. It is supported in the usual way by beams and stays, the beams being each 8 ft. apart. The decks are three in number, and have a very considerable area. The main deck, which, with the hold, is for cargo, is constructed of steel, and the two decks above are of wood. The distance between each is 9 ft. The top deck is for promenading, and on the middle deck there are large saloons. Abaft of the engine space there is the Chinese saloon, 73 ft. long and 45 ft. mean width; the only furnishing required here is deck seats or lounges. Forward of the boilers there are several large staterooms for European passengers. In many respects these are models, not only of comfort and elegance, but also for size. One of the rooms, for two ladies, is 16 ft. by 10 ft. The dining saloon is at the extreme forward end of the deck. It is 44 ft. long by 36 ft. mean breadth, and is seated for twenty passengers. The shade decks are carried on stanchions and stringers, strongly braced where necessary to prevent racking. There are two longitudinal bulkheads along the center of the ship for about one-third of the length, attached to the steel deck and the bottom.

Remarkable as the vessel is in some respects, the engines form the principal features of the design. They are compound beam engines, on a plan never before adopted on board any steamer. The cylinders are 40 in. and 72 in. with a 10 ft. stroke. The cylinders incline toward each other at the head, the crossheads of the piston rods being connected by links to the same (the forward) end of the beam. The one cylinder exhausts direct into the other without any other receiver than the pipe connecting the top of the one with the bottom of the other. The beam is constructed on the usual American plan, with cast iron center and forged steel strap, but with more accuracy of fitting than our American cousins are content with. It is 11 feet maximum breadth, and its length 23 ft. centers. Gallows frames built into the ship support the beam. The paddle wheels have feathering floats, and are constructed entirely of steel. They are 21 ft. in diameter and 15 ft. face. Steam is supplied from three double-ended boilers, placed athwartship, and fired from the wings. These boilers are 14 ft. in diameter and 14 ft. long, and have eighteen furnaces, 39 in. in diameter, with a heating surface of 9,000 square feet. The indicated horse power is 3,000, and the speed attained 16¼ knots per hour.

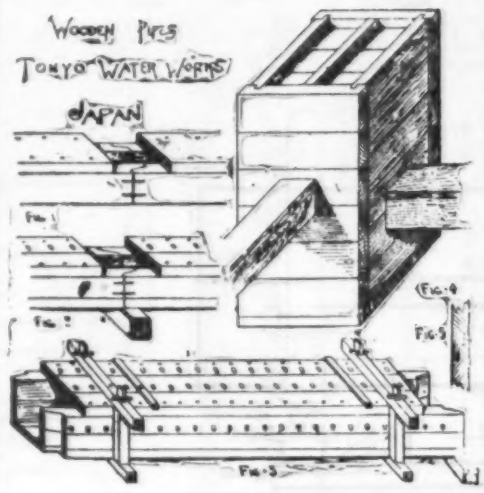
The originality of the design, and the success which has attended the vessel in trading, are excellent testimonials of the skill of Messrs. Inglis in the conception of this description of vessel. Two fine vessels were constructed for the Mensagerias Fluviales of South America with similar engines, but of 2,100 indicated horse power. Messrs. Inglis have built altogether twelve river steamers of this peculiar type, all of which are still running, and are favorite passenger ships.—*Engineering.*

THE WATER SUPPLY OF TOKYO, JAPAN.*

By Y. NAKAJIMA, C.E.

TOKYO, or formerly called Yedo, is the present capital of Japan, and is the largest city in the empire. On the south it is bounded by the sea, and on the north and west there are many hill ranges. The heart of the city is traversed by many transportation canals. Its total area is 15,279 acres or 23·87 square miles. The total length of the streets is about 477 miles, and they are in general very narrow. Most buildings in the business part are two stories high. The population of the city proper is 1,210,000, or 72·7 persons per acre.

"When General Iyeyas decided to make Tokyo his headquarters, it was but a small town. But his policy was to have all the nobility under his eye, so he ordered them all to reside in Tokyo; and this caused a rapid increase in the population, as may be understood when it is remembered that some had armed followers to the



number of one thousand, and each follower had his family." The water obtained was, in general, very bad, and in many places it contained salts and was not fitted for drinking purposes at all. Also in some parts the supply occasionally failed. Consequently, as the population increased, the necessity for water supply was greatly felt, and the following works were carried out, which, without material change, have supplied Tokyo until to-day.

In 1620 (though some say a little later), one of the Shogun (General) ordered a man who had lived a long while in the neighborhood of Tokyo to consider the question of water supply for the city. He proposed and constructed what is now commonly called the Kanda system. The three ponds, namely, that of Enokashira, Zenpukuji, and Myo-syoji, are the principal sources of this system, and a part of the water of the Tamagawa canal helps them at present. The respective heights of these ponds are 147·5, 150·5, and 137·5 feet above the sea. The waters from these sources are combined in one canal and are distributed through a part of the city by various wooden pipes. This system supplies the wards of Koishi-Kawa, Kanda, and part of Niphon-bashi. Its daily supply is about 17,000,000 U. S. gallons.

The other is called the Tamagawa system, and is more important than the one already described. The Shogun noticed the insufficiency of the existing system, and in 1651 he ordered a nobleman to consider its extension, or, more properly, the introduction of a new supply. It is said that, accordingly, two farmers who were well acquainted with the surrounding country were appointed to make surveys and report. It is also said that at that time there were no levels and almost no surveying instruments of any description at all. However, somehow or other, they made the survey and recommended drawing the water from the Tamagawa River. The plan was adopted and the work was begun in April, 1653, and completed in November of the same year. They built a dam across the river so as to turn the water into the canal. The height of the water surface of the canal near the dam is 404 ft. above the sea. The total length of the open canal from the dam to the Yotsuya gate is 26·6 miles. From the dam, for about 0·7 of a mile, the width of the canal is about 30 ft., and the width of the remaining portion decreases from 24 to 18 ft. "The canal was skillfully placed along the plain which extends from the dam to Tokyo, so that no high embankments or deep excavations were needed. The velocity of the water is rather great, but it is quite uniform from one end of the canal to the other. The high velocity is beneficial, because it prevents the growth of and obstruction from aquatic plants, and the injury to the banks is less than would be expected, as the earth here hardens under the action of water." This canal serves also for irrigating the lands along the line. There are also several mills. The gate at Yotsuya regulates the water flow to Tokyo, and the extra water is drawn off by a waste pipe. The daily supply by this system is about 24,000,000 gallons. This supplies the following wards, namely: Akasaka, part of Yotsuya, Azabu, Kochi-Machi, Shiba, Kyo-bashi, and part of Niphon-bashi. The total number of the people depending upon these two systems is about 400,000.

There is another, called the Chigawa system, which supplies a part of the wards of Koishi-Kawa and Hongo. The daily supply is 1,400,000 gallons.

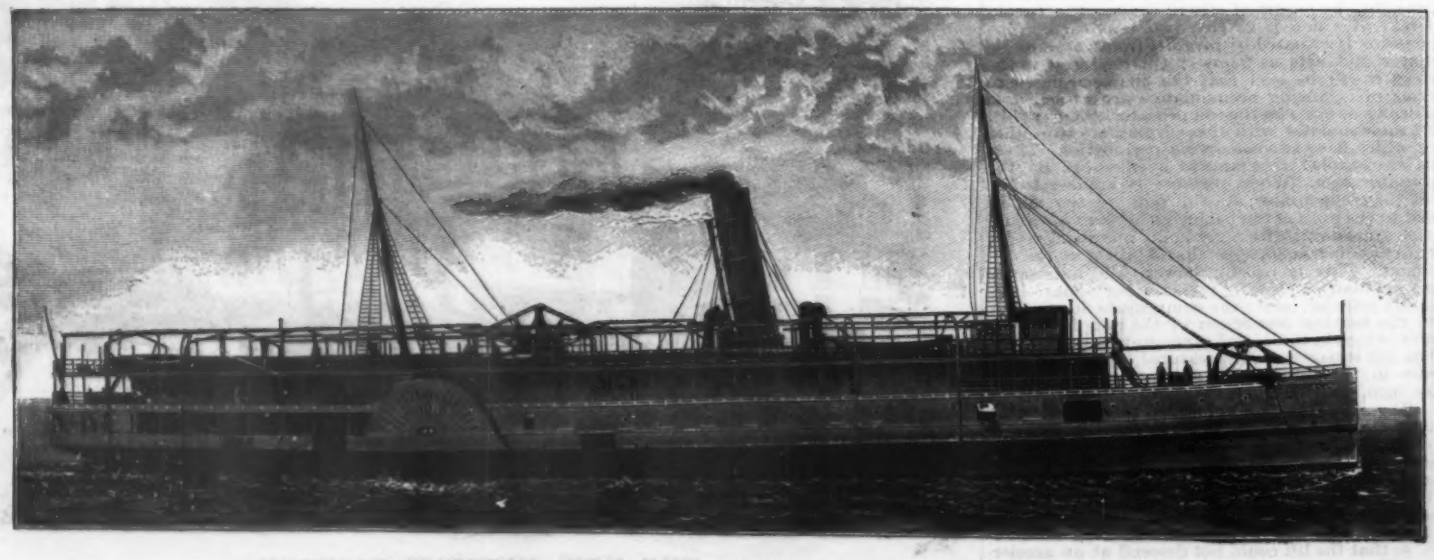
Besides the above three systems, there had been introduced three or four other systems at various times, but none of them was successful, on account of excessive cost of maintenance, and all had been abandoned.

The distribution pipes are generally of wood; in dry places Retinispora obtusa is used, and in wet grounds pine is used for pipes. There are many forms of wooden pipes in use. When the internal diameter is much less than 6 in., a round timber with a circular hole through is used. When the pipes are a little larger, then a square timber is hollowed out so that its section looks like a U, and the top is covered with a plank which is spiked on (Fig. 1). The joints are well calked with a fibrous bark so as to prevent leakage. The connections between the ends of adjoining pipes are formed by chamfering the end of one pipe and enlarging the interior of the end of the next, and driving the first into the second (Fig. 1). The pipe of this form is used when the side of the interior hole is less than 6 in. In larger pipes the section is either square or rectangular, with the broad side laid (Fig. 2). The thickness of the planks forming the sides is from 2½ to 6 in. When these pipes are subjected to a considerable pressure they are braced by frames of square timbers, as shown in Fig. 3. The largest wooden pipe in use is 3 ft. in height by 4½ ft. in width, and the smallest one is 3¼ by 3¼ in. The largest stone conduit is 5 ft. in height by 6 ft. in width, and the smallest one is 1 ft. 6 in. by 1 ft. 6 in. The total length of the wooden pipes now in use is 533,790 ft., or 101·1 miles, of which 240,470 ft. belongs to the Tamagawa system, 221,210 ft. to that of Kanda, and the balance to the Chigawa system.

The total length of the stone conduit is 24,625 ft., of which 12,070 ft. belongs to the Tamagawa system and the balance to that of the Kanda. The depth of the distribution pipes is from 4 to 18 ft. below the surface of the ground. The wooden pipes last from ten to twenty years, according to the nature of the ground. The distribution pipes of the three systems are not connected at all, though in some parts they come close together. Whenever there is an abrupt change in level, or there is a branch pipe, a square box is used, as shown in Fig. 4, whose sides vary from 2½ ft. to 6 ft., according to the sizes of the pipes. There are a great variety of the forms of the boxes, according to the locality, the pressure, head, etc. In some parts, boxes are put simply for inspecting the flow and the quality of water. They may, to some degree, serve to make the flow in the pipes uniform. "The water is not carried from the mains into the houses, but is delivered into wells, which are usually on one side of the streets." Commonly the connection of the well to the distribution pipe is made by inserting one end of a 2 in. iron pipe about 3 ft. long to the side of the distribution pipe and the other end to a square wooden box 1 ft. 2¼ in. wide and 1 ft. high, the thickness of which is about 2½ in. The connection of this box to the well is made commonly by a wooden pipe, the diameter of which is 2½ in.

The wells are generally lined with wooden planks 5

* The materials for this description were furnished to the author mostly by Mr. R. Hara, C.B. of Tokyo-Fu, and a great deal is quoted by permission from Prof. W. S. Chaplin's paper, read before New England Water Works Association.



THE LIGHT DRAUGHT PADDLE STEAMER HONAM

or 6 in. wide and 2 in. thick, fastened together by several bamboo bands in a cylindrical form. The height of each of these wooden cylinders is about 6 or 8 ft., and their diameter varies from 3 to 4 ft. The depth of the wells depends upon that of the distribution pipes near by. The top of the cylinder projects about 3 ft. above the ground surface, so as to prevent the danger of falling in. The total number of these wells now in use is 7,765, of which 2,935 belong to the Tamagawa system, 3,704 to that of Kanda, and the balance to the Chigawa system. "The ends of the mains are carried down to the banks of the canals, rivers, and the shore of the bay, and the water is allowed to escape freely, thus reducing the great pressure in the pipes and preventing injury to them." In this way a great deal of water is wasted, though the exact amount is not known.

Chemical examinations have shown that the water is contaminated in the distribution, for samples taken from the conduits showed no pollution, while those taken from the wells in the lower part of the city were decidedly bad. The analysis also shows that the water of the Tamagawa is much superior to that of Kanda. Several theories have been advanced to account for its contamination. One is, that as the pipes are usually below the level of the ground water, though the head is greater inside the pipes, there is a continual diffusion of the impurities in the ground water through the wood into the pipes. Another and more probable hypothesis is that, owing to the constantly changing level of the water in the wells, which arises mostly from the small size of the pipes which connect the mains with the wells, the impure water from ground makes its way through the leaky linings into the wells, and that the water thus polluted is carried at times back into the mains." In another experiment water was taken from the different parts of the systems on the same day, and the analysis of these different waters showed that the further the water flows through the distribution pipes, the greater is the contamination, and in the thickly settled places the impurities are found to be more than in the thinly inhabited portions.

The water rate for one well is $4.50 per annum. A fountain rate is double, and a waterfall rate is ten times that amount. The average annual cost of maintenance for the three years 1883, 1884, 1885, is $27,800.

Nearly all the people of the Fukagawa ward, and about one-fifth of those of the Honjo, altogether 89,450 in number, use water brought daily by boats from some distant rivers or from the outlets of the already mentioned systems. The quantity conveyed daily by these boats is 77,200 gallons. The daily cost of transportation is about $45, or $16,425 per annum.

In the places where the above systems do not extend, the people use the water of the common wells and of artesian wells. The total number now in use in the capital is 33,952. In general, the water from the common wells is much inferior to that of the already mentioned systems.

As the water of these systems has no head, and as in many places it can hardly be obtained with convenience, the losses due to fire are quite great. The area covered by the buildings burned in 1883 is thirty-seven acres; in 1884, twenty-six acres; and in 1885, thirty-two acres. Nearly all the buildings are only one or two stories high, so that the losses due to these fires are not so great as might be supposed. It may be fairly estimated that the losses from buildings burned in these years are $669,000, $473,000, and $585,000 respectively.

About two hundred and fifty years ago, very little was done toward systematic water supply, even in London; and the waterworks of Tokyo were quite large for that period. In fact, up to that time, there had been no such extensive waterworks constructed in the world except at Rome. However gigantic, as it may have appeared at the time of its construction, it cannot be comparable, in many respects, with the present systems in America and Europe, and therefore it will, no doubt, be replaced by some better system in a few years.

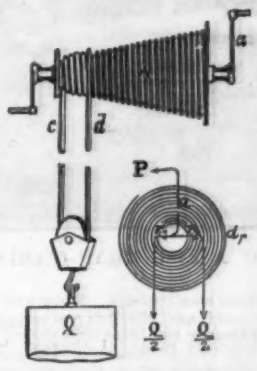
A RUSSIAN RAILWAY ACCIDENT.

On the 29th of October last the Czar of Russia and his family were traveling in an imperial train, and, it is said, the Czar, impatient at the slow speed usually run, and which was established as the safe speed, ordered the velocity to be increased. At Rorki the train jumped the track and a terrible scene followed; twenty persons were killed and eighteen wounded. Happily the Czar and family all escaped. The *London Graphic* gives with our engraving the following particulars: The imperial train is always accompanied by another, which either precedes or follows it. In this case their Majesties were in the first, the other being about an hour's distance behind. On arriving at a small station, the occupants of the latter heard of the accident, and at once went on to the scene. The last three carriages, out of eighteen, were still on the rails, but the fourth was driven sideways, and overhung a steep incline of some forty yards. Beyond appeared a second-class carriage in fragments, numbers of bodies covered up, and broken timbers, planks, and general wreckage. On proceeding further, the full effect of the disaster was apparent. One carriage was a mass of splinters, with the roof lying crosswise on the crushed woodwork; another was wrecked, but still partly standing, while two next the two engines were apparently little damaged. Out of the most completely ruined carriage, three-and-twenty living souls were rescued, with one or two exceptions, almost unbruised. It was the dining saloon, and there the Czar and Czarina, with every child of theirs save the little Grand Duchess Olga, were seated with the suite at dinner. A sudden shock sent them down on the floor, then followed a fearful crash, and then a terrible silence, broken by the shrieks of the dying and wounded. The Empress was one of the first to extricate herself from the wreck, with the cry, "Where is the Emperor? Where are my children?" But Heaven gave them all back to her from that heap of ruin, and almost unbruised. The escape of the little Olga Alexandrovna was equally miraculous. She and her English nurse were hurled twenty feet down a steep slope, yet were unhurt. When the little Princess saw that her father and mother, her brothers and sisters, were safe, she threw her arms round her nurse's neck, crying, "How I should like to throw my arms round God's neck, and kiss Him for saving us all." Meanwhile, although the Czarina's hands were badly bruised and cut, she went about among the wounded, as they were successively extricated, like a ministering angel. The Czar and the Grand Dukes Nicholas and George Alexandrovitch were everywhere, lending a helping hand in extricating the wounded and the dead. We subjoin a key to the plan of the Czar's dining car:

1, Count Tcheremetieff; 2, General Sinovieff; 3, Countess Tcheremetieff; 4, the Emperor; 5, Countess Kutusoff; 6, General Richter; 7, Grand Duke George; 8, Dr. Hirsch; 9, Painter Zichy; 10, Count Kutusoff; 11, the Heir Apparent; 12, General Possiett; 13, the Empress; 14, Count Voronzoff Dashkoff; 15, General Martinoff; 16, Grand Duchess Axenia; 17, General Tcheverin. A, B, C, D, show the doors to the dining car, at the large table in the center of which the above were seated.

A CONICAL DRUM WINDLASS.

The windlass represented by the annexed engraving is a modification of the differential windlass. On the



surface of the conical drum, A, a helical spiral groove is cut, in which the lifting cable runs. On turning the drum by means of a handle, *a*, the rope, *d*, is rolled up, while the rope, *c*, is unrolled, so that as the drum makes a revolution, the weight mounts in quantity H equal to

$$H=\frac{2r_2\pi-2r_1\pi}{2};$$

r_1 and r_2 designating the radii of two consecutive parts of the groove. If this difference be represented by d_2, the following formula, $H=nd2\pi$, gives the height of lift of the load when the number of coils of the cable is *n*.

The force, P, which must be developed in order to raise the weight, Q, is—deduction being made for friction—given by the following formulæ:

$$P=\frac{\frac{Q}{2}(r_2-r_1)}{a}=\frac{Qnd_2}{2a}.$$

The drum, being given the value of *a*, can be estimated so as to vary the rotation $\frac{P}{Q}$ within considerable limits by modifying according to requirement the number, *n*, of coils of the rope.

Designating by *m* the total number of spires of the drum, the handle of the windlass may be turned a number of times represented by (*m*—*n*), until the rope has passed to the side of the windlass at the opposite extremity. The total height of the elevation of load is then $H=(m-n)\,n\,d_2\,\pi$. An ordinary differential windlass, able with a force, P, applied to the extremity of a lever, *a*, to raise the weight, Q, after (*m*—*n*) rotations to the total height, H, should have a length somewhat greater than that of the windlass we have just described. The excess of length should be 2 (*m*—*n*)—*m*, or of *m*—2*n* in thicknesses of rope.—*Centralblatt der Bauverwaltung.*

ON OCEAN TEMPERATURES IN RELATION TO SUBMARINE CABLES.*

By Wm. Lant Carpenter.

In the paper read by Mr. Stallibrass on November 10, 1887, "On Deep Sea Soundings in Connection with Submarine Telegraphy," and in the discussion thereon, no reference was made to temperature sounding and the influence of temperature upon (1) the conductor, (2) the insulation resistance of cables. Ocean temperatures varied, even in the tropics, from 85 deg. Fahr. to 30 deg. Fahr.

The resistance of a conductor at 85 deg. was 10·8 per cent. greater than 30 deg., but the insulation resistance of a cable at 30 deg. was thirty times that at 85 deg. Calculations and diagrams to show this, founded on data obtained from the Accra-Sierra Leone cable, laid in 1886, and kindly supplied to the author by Mr. Henry D. Wilkinson (member), were exhibited. All insulating substances were not equally thus affected. The influence of pressure upon insulation resistance was touched on in passing, and the author went on to describe the method of ascertaining temperatures at great depths in the sea. Ordinary self-registering thermometers indicated too high a temperature, the pressure (1 ton per square inch for every 800 fathoms deep) contracting the bulb and forcing the liquid up the stem. This was first successfully obviated in the Miller-Casella thermometer, in which the ordinary bulb was surrounded by a second, the intervening space being partly filled with fluid. The author, under Captain Calver, in H. M. S. Porcupine, had had the first use of these at sea in 1869. Some of them were exhibited, through the kindness of the Hydrographic Department of the Admiralty.

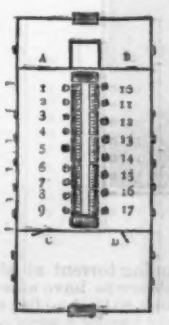
Their indications were controlled also by the Siemens electrical thermometer (exhibited at the meeting), in which two coils of precisely similar construction and equal resistance at the same temperature form the two arms of a Wheatstone bridge. One of these is attached to a cable and lowered into the sea, and the bridge is balanced by altering the temperature of the water in which the other coil is placed on deck, when a thermometric observation of this latter gives the temperature of the submerged coil. Some deep sea thermometers contrived and manufactured by Messrs. Negretti & Zambra were also exhibited, in which the instrument was reversed, and the mercurial column thereby detached, when the sounding line began to be hauled in.

Mr. Carpenter then made a brief reference to the Challenger expedition, which lasted three and a half years, traversed 70,000 miles, and established 362 observing stations, at each of which bottom temperatures were observed; and he then summarized the work of the United States steamer Tuscarora, sent out to ascertain the most practicable cable route between the Pacific seaboard of the United States and Japan, in the course of which 483 soundings and bottom temperature observations were taken. The method of "serial temperature soundings" was then briefly described, by which the relation of temperature to depth was ascertained, and the way in which these results were plotted in "temperature sections" was then explained. Several of these, obtained during the cruise of the Challenger, were exhibited. Attention was first called to a section across the North Atlantic from Madeira, through the Azores and Bermuda, to Halifax. About two-thirds of this mass of water was seen to be below 40 deg. Fahr., the bottom temperature varying from 34·8 deg. to 38·7 deg. In the Northern Pacific the bottom was colder, and the volume of water below 40 deg. larger. In the Equatorial Atlantic the bottom was equally cold, and the "bathymetrical isotherm" of 40 deg. came nearer to the surface than elsewhere, so that as the surface was hotter, the fall in temperature relatively to depth was much more rapid.

The thermal conditions of partially land-locked seas were then contrasted with the above; in the Mediterranean, no lower temperature than 54 deg. Fahr. was met with, although depths of 2,000 fathoms were sounded, while in the Atlantic, a short distance off, at the same depth, 36 deg. was met with. Similar instances were given, among them the Red Sea, 71 deg. being (as far as was known) the minimum; the Sulu Sea, on the line of the cable between Singapore and Hong Kong, where the minimum is 50·5 deg., even at 2,550 fathoms, 32 deg. to 33 deg. being the temperature at that depth in the Indian Ocean near; the Celebes Sea, and others.

Here were well-authenticated facts, and what was the explanation of them? Without going into a general discussion of oceanic physics, for which that was not the place, he would venture to say that the only satisfactory explanation to his mind lay in the idea, as to the truth of which a vast body of evidence might be brought forward, that there was a constant vertical circulation of the waters of the great oceans, due to the differences in specific gravity, caused by differences in temperature; that the upper layers of water were moving from the equator toward the poles, and the lower layers from the poles toward the equator, their movement being affected also by the earth's rotation; that such seas as the Mediterranean, etc., were cut off from this general oceanic circulation by submarine ridges, so that their water at a greater depth than these ridges

* Abstract of paper read before the Society of Telegraph Engineers and Electricians, November 8, 1888.



PLAN OF THE CZAR'S DINING CAR.

THE CZAR'S TRAIN IMMEDIATELY AFTER THE ACCIDENT.

was perfectly stagnant, and no interchange with the colder water of the great oceans occurred; and finally that the cause of this circulation was more probably to be found in the polar cold than in the equatorial heat.

Mr. Carpenter concluded by citing authorities in support of this view, and by very briefly indicating the effect of this circulation upon climate generally.

THE SALMON FISHERIES OF THE COLUMBIA RIVER.*

THE salmon of the Columbia River, from the time of entering fresh water, cease, with insignificant exceptions, to take food, and hence they cannot be taken with the hook. This conclusion has been very generally reached and accepted. When captured, their stomachs have invariably been found empty upon examination.

In and near the estuary they are taken by means of fixed, movable, and floating nets.

FIXED NETS.

These are commonly called fish traps, or pound nets. A row of small piles is run out from the shore or shoals toward the deep water where the fish run. At the outer end they are driven around a rectangular inclosure or pound. Netting of wire or twine, with a two inch mesh, is laid on these piles in such manner as to prevent the passage of the fish and lead them into the pound, from which they cannot escape and from which they are easily taken. Sometimes slats two inches apart are laid along a portion of the piling instead of netting. The size of the mesh of the netting determines the size of the fish captured. The fish are taken alive and uninjured, and if any object were to be gained by rejecting sizes or varieties, it would be a feasible matter to have them thrown back into the water. Fig. 4 shows the manner of taking the fish from the net.

MOVABLE NETS.

These are the ordinary seines placed and handled from shore or shoals. They are usually drawn by horses. The seining grounds are about the upper limits of the estuary of the Columbia. The seines take the fish alive. They are about 900 feet long, with 2½ inch mesh outside and 3 inch inshore. (Fig. 5.)

FLOATING NETS.

These are the well known gill nets that are carried in and placed from small boats. They are spread in and near the channel, and the fish are caught by the gills while attempting to pass through them. The nets are placed and allowed to float with the current and tide for various distances, when they are hauled into the boat and the fish removed at the same time. In this system the fish are killed in the capture. The size of the mesh determines the size of the fish taken, and this is so fixed as to allow all small fish to pass through. The great bulk of this sort of fishing is done in and about the mouth and estuary of the river, and by fishermen from Astoria. On an average, the gill nets are 1,800 feet long, and from 20 to 30 feet deep, with meshes of 4¼ inches. Lead sinkers are placed at intervals of 12 inches, in order to hold down the lower edge. The whole number of these nets operating in and about the mouth of the river is about 1,600. The whole length of these 1,600 nets is about 2,880,000 feet, or about 545 miles.

WHEEL AND DIP NET FISHING.

From the mouth of the river up to the Cascades, the fishing is done in a similar manner, the volume gradually decreasing until this point is reached. At this point the whole style of fishing changes, and we have the old fashioned dip net and the wheel, both here and at the Dalles, 50 miles further up the river. At these points the fish are caught while endeavoring to pass the rapids. Here are many places where the velocity of the water is so great that the fish seek places in passing where it is the least. The friction of the rocky bed and shore makes these points immediately along shore, where one can stand and reach the fish with dip nets attached to long poles as they struggle by. These have been the favorite fishing spots of the Indians from time immemorial. Here the tribes came in summer, pitched their camps, and caught their winter's supply of food. Fig. 6 shows this sort of fishing at the Dalles, where it is still extensively carried on. The Indian has been driven from the field, and white men have obtained from the government the exclusive right to fish. Indians are still employed, and the illustrations show both Indians and white men at work. The fish are carried to the packing house by the squaws, who use large gunny bags suspended on the back by a strap around the forehead. The bag is held open by one hand while the other hand dumps the fish in. One is shown in the act of placing a forty pounder in the bag. The quantity of fish caught by dip nets is surprising. In one day during the season of 1887, at the Dalles fishery, four nets took 22,000 pounds. In one season four nets took 800,000 pounds.

The wheel (Figs. 7 and 8).—The wheel is the apotheosis of the dip net. Imagine a white man of inventive mind standing on one of those bold rocks wearily pushing a dip net through the foaming torrent at his feet. His first thought would be a desire to have a net that would be in the water all the time, so that no fish should be able to get by. If he could handle a succession of four or five nets, the thing would be accomplished. To place them on the periphery of a wheel with a horizon-

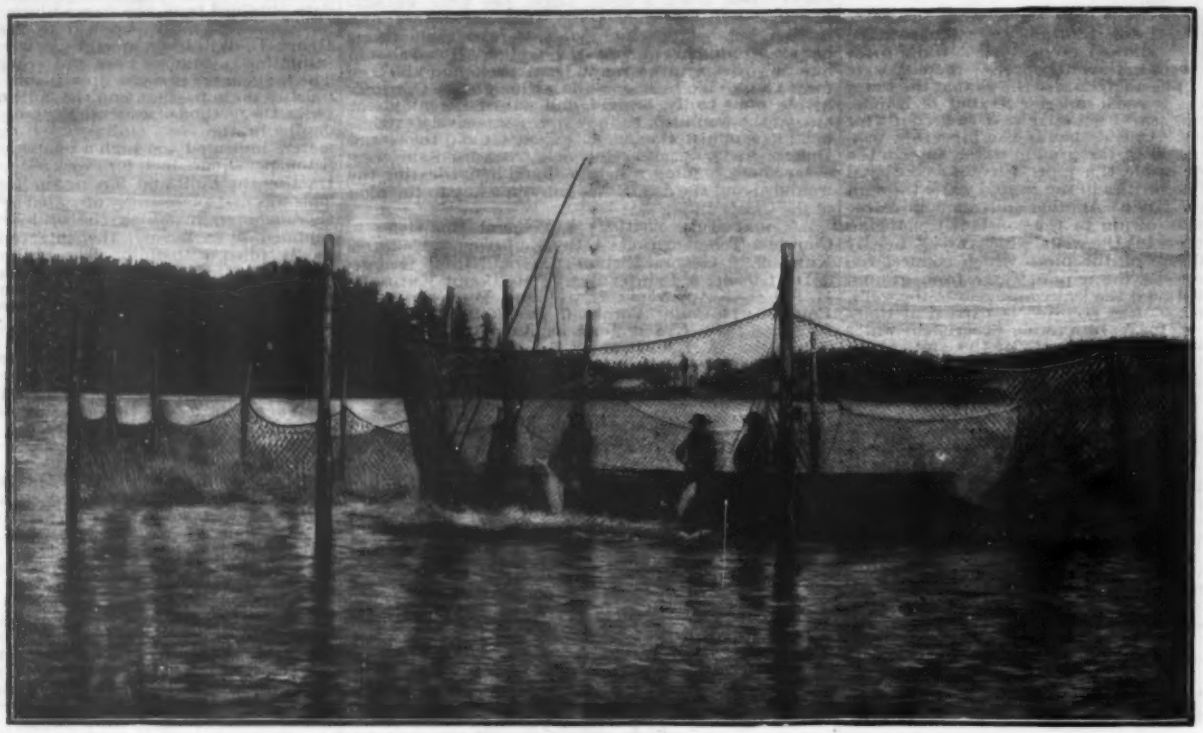


FIG. 4.—POUND OF A FISH TRAP—TAKING OUT SALMON

FIG. 5.—SEINING.

* Continued from SUPPLEMENT, No. 677, page 10803.

FIG. 6.—DIP NET FISHING AT THE DALLES.

FIG. 7.—FISH WHEEL IN OPERATION.

FIG. 8.—FISH WHEEL IN OPERATION.

FIG. 9.—SCOW WHEEL IN OPERATION.

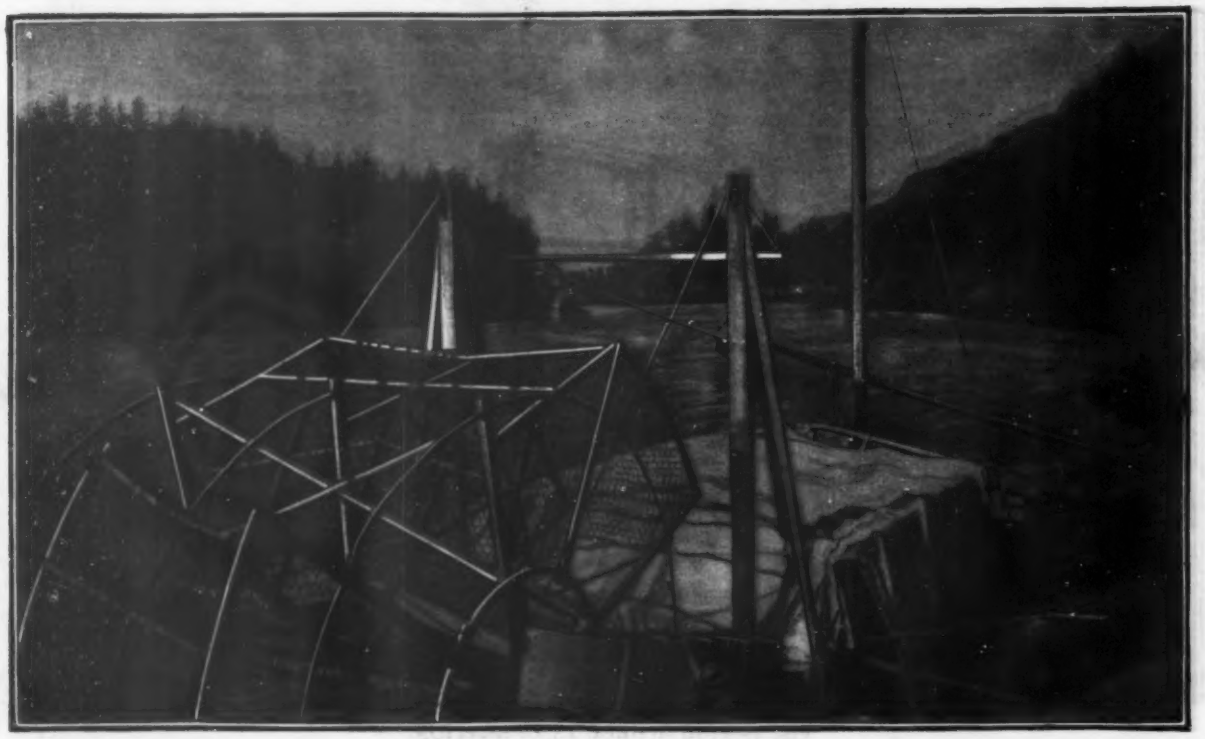


FIG. 10.—SCOW WHEEL IN OPERATION.

FIG. 11.—INTERIOR VIEW OF A CANNERY.

tal axis, the wheel to carry paddles to make the current of water revolve it, would almost be a logical sequence of the thought. Elaborate the idea with some details of making the nets as wide at the mouth as possible, and extending the bottoms inward to connect with inclined troughs placed along the axis of the wheel, so that when it revolved, gradually increasing the angle of the bottom of the net with the horizontal, the fish would gravitate toward the trough and slide out into a box placed below the shore end of the axis of the wheel, and we have a device for catching fish with a dip net that would appear simply divine in the eyes of the untutored savages who wielded it so long under the conditions of this locality. The success of this fishing machine depends on the fact that there are many points along the rapids of the river where the trails of the traveling salmon come together alongside of rocky points projecting from the shore. A wheel placed so as to cover such a trail will be tolerably certain to catch the majority of the passing fish. There are only a few points where these conditions are maintained constant during the varying stages of the river, and where wheels may permanently be placed, and hence some wheels are placed on the ends of scows (Figs. 9 and 10) which can be moved from point to point to meet the varying conditions of river stage.

METHODS OF MARKETING THE FISH.

The fish are placed upon the market in three different ways—fresh, canned, and smoked. The fresh fish are placed in large boxes and sent to the local markets. For the distant markets these boxes are filled with ice carefully packed around the fish, and this ice is renewed occasionally during the journey to the interior and to the Atlantic coast. The bulk of this business is carried on from the Cascades and the Dalles, where the fish are caught alive in the wheels and dip nets. Hundreds of tons are annually shipped East in this manner.

The canned fish are prepared and handled by extensive establishments called canneries. (Fig. 11.) Here they are cleaned, cut up, boiled, and canned. The great bulk of the fish are marketed in this manner. They are packed up in 1 pound cans, forty-eight of which are placed in a box and called a case. The case is the trade unit. The fish are caught by the fishermen and bought from them by the canneries, the latter furnishing the boats and nets without charge. The fish traps, however are not owned by the canneries.

The smoked fish are prepared in the usual way, but the quantity is comparatively small. The canned fish are shipped to Europe and the Eastern States.

STATISTICS.

The salmon fisheries of the Columbia River were established twenty years ago, in 1866. In that year the product was 4,000 cases, which, at the then cash price of $16 a case, made a total value of $64,000. Ten years later, in 1876, the catch was 450,000 cases, or an increase in that decade of nearly 11,250 per cent., and then worth $4.50 per case, and of a total value of $2,025,000. Seven years later, in 1883, the product had increased to 630,000 cases, of the value of $5 per case, making a total value of that year's catch of $3,150,000. That we may comprehend better the magnitude of this great industry, it must be remembered that the average weight of each case, including the cans, is about 72 pounds, as the ordinary size can holds 1 pound net of prepared fish, there being 48 cans in each case. So the catch of 1883, taking that year for an illustration, was about 22,680 tons of prepared salmon, or enough to load two hundred and twenty-six trains of cars of ten cars each, each car containing 10 tons of salmon, or twenty-three ship cargoes of 1,000 tons each. In this industry over 40 canneries are in operation, over $2,000,000 of permanent capital invested; 1,548 boats, including 10 or 12 steam-tenders, are employed, and employment is given during each month of the fishing season to several thousand men, the number of men employed in 1886 being 7,596; of these, 4,200 were white persons and 3,396 Chinese. The above relates only to the catch by gill nets alone on the Columbia River, while about one-third more, it is estimated, are taken by seines, traps, and wheels. The number of fish caught by gill nets alone in 1886 was 1,315,800.

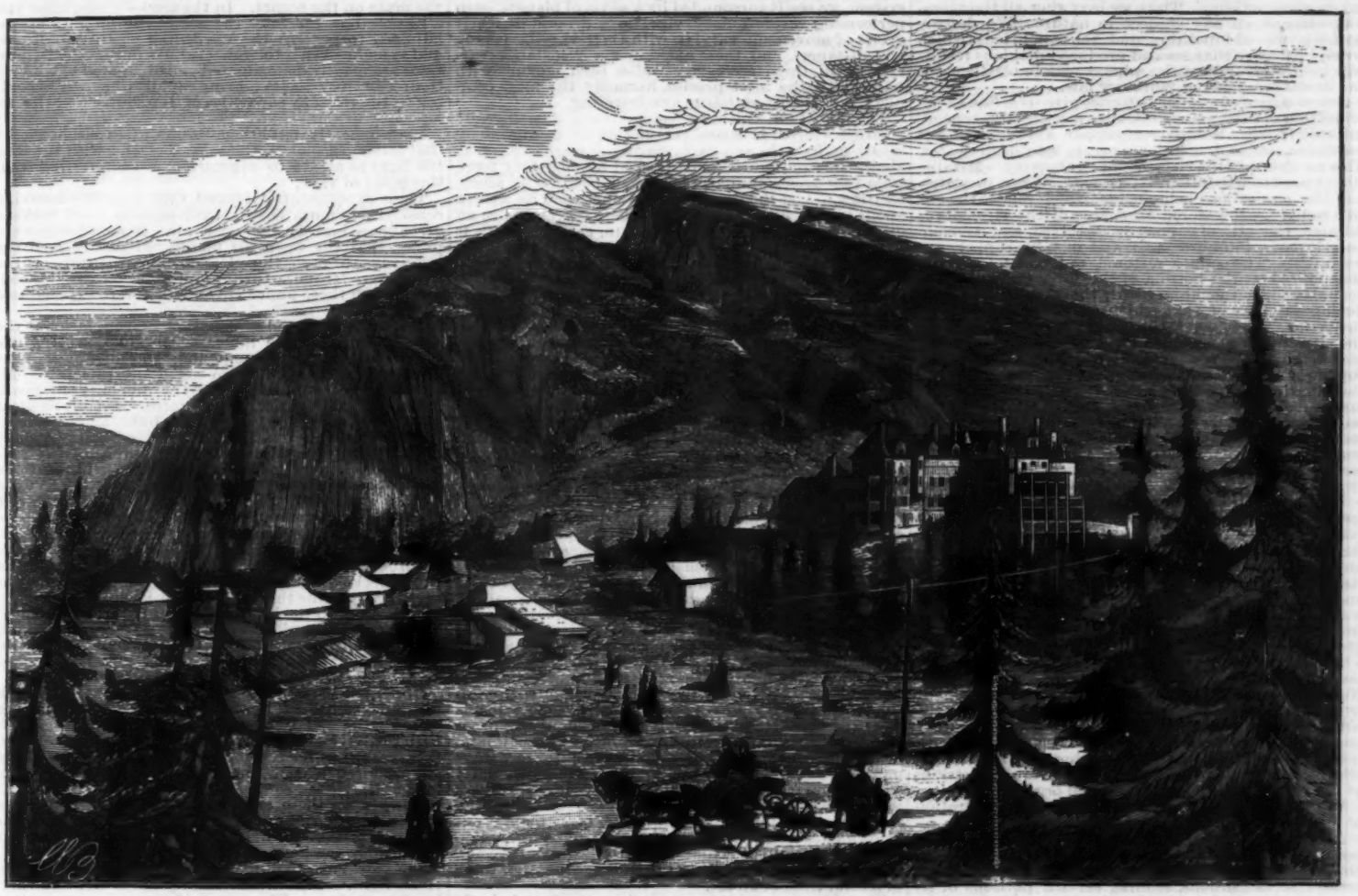
BANFF.

BANFF, on the Canadian Pacific Railway, is situated on the banks of the Bow River, close to the Rocky Mountains and to the frontier of the province of British Columbia, 2,343 miles west of Montreal. Banff is situated in a district of romantic and picturesque mountain, river, and lake scenery, of great extent, reserved for the "Canadian National Park," and it is the site of medicinal hot springs, charged with sulphur and iron and salts of great healing efficacy for many bodily ailments. These springs arise in the Sulphur Mountain, which is 4,500 ft. in height; the flow of water is about 1,200,000 gallons a day, and its temperature at the source is 115° Fahrenheit.

The Banff Sanitarium, under the charge of Dr. R.G. Brett, M.D., Medical Director, is a large building of three stories, beautifully situated, which has comfortable rooms, attentive servants, well furnished tables, and broad piazzas, with agreeable walks in the grounds, provision for cricket, lawn tennis, and other games, and delightful rides and drives in the neighborhood. Its site being 5,400 ft. above the sea level, the air is pure and bracing, while the mountains afford shelter from cold or rough winds, and there is almost an entire absence of clouds or mists.

The Canadian Pacific Railway Hotel at Banff contains more than two hundred rooms, with ice cold mountain-spring water throughout the house and bath houses supplied from the upper hot spring brought down 800 ft. in iron pipes. Several hundred feet below this spring are two others, within a hundred feet of each other. One is in a cave, or grotto, about 25 ft. in diameter, with a vaulted dome. It is entered by a tunnel a hundred feet long, and lighted by a natural opening at the apex, about two feet by three. In the grotto is a swimming bath, surrounded by pretty stalactites, with water about 5 ft. deep boiling up from the sandy bottom, temperature, 95 deg. Cold water pours from one of the shell-shaped stalactites in sufficient quantity to make a cold shower. A hundred feet from this is another large pool, 20 ft. across, about the same size, and, being in the open air, the warm water can be seen boiling up through the sands. Both this and the cave springs have streams flowing from them as large as a first-class fire engine could pump. The cave spring discharges at its outlet without coloring the soil along the rivulet, while the other makes a deposit as white as lime. This deposit is a magnesiate of lime impregnated with iron and sulphur.

The mineral waters differ from each other, not only in the temperature of the waters, but also in their chemical composition. The temperature of the different springs varies from 85 deg. to 125 deg. Fahrenheit. They have proved of the most striking benefit to those suffering from various forms of rheumatic affections, scrofulous tumors and skin diseases, malarial poisoning of long standing, anæmia, and the troubles which have their seat in weakness of constitution or general debility. By allaying muscular and nervous irritability through their soothing influences on the peripheral nerves, sciatica and other neuralgias are greatly benefited. Owing to the saline qualities of some of the springs, certain complaints of the kidneys and liver, renal and biliary calculi, and catarrhal affections of various mucous membranes, are successfully treated.—*Illustrated London News.*



BANFF, ON THE CANADIAN PACIFIC RAILWAY.

THE UNIVERSALITY OF VIBRATIONS.*

By C. C. HASKINS.

VIBRATIONS, in the most limited sense of the term, are defined as minute reciprocal motions of the particles of an elastic body when they are thrown out of equilibrium. Oscillations embrace a class of movements which may be termed vibrations of greater dimensions—the two differing only in degree. These may traverse vertical arcs or horizontal curves, parts or the whole of circles or ellipses. Amplified still further, we find movements embracing extended cycles of time, yet ever returning to a former condition or position. These are all, generically speaking, vibrations, differing only in the one element of time. We may go farther and include as vibrations all that class of changes or motions which have the one common similarity of starting at a given point, origin, or condition, and having accomplished a change of place, form, or position—a cycle of movement or transition—returned to their pristine status; again and again repeating this round of differing phases.

These periodic rounds, whether comprising two or more changes, whether molar or molecular, I have classed as vibrations, and within this scope I include the movements of elastic bodies, springs, chords, gases, etc., the segmental action of suspended bodies like pendulums, the gyratory movements of storms, the progression of planets in their orbits, and those chemical changes which are ever active in nature, producing combinations in the mineral, animal, and vegetable worlds, by which the various conditions of growth and decay so constantly and regularly succeed each other.

These mutations—now noiseless, hardly perceptible in their slow progress, at other times bold, rapid even to instantaneity—eventuate in the same accomplishment, the restoration of the elements to their simplest form and their recombination in the chemical world, in the world of motion—to repeat for all time this round of change, this following in the beaten path of nature's ages—periods of time of which the mind of man can take no cognizance.

Take an example: An internal chemical commotion occurs beneath the crust of the earth's surface. Inharmony among the existing elements as combined results in greatly increasing the volume of these, and the stored-up energy heretofore confined is set free. This energy is expended in the line of least resistance, and the result is an upheaval of the earth's surface. A mountain is born. One limit of the vibration is reached. Rains descend upon the upheaved surface, penetrate the crevices of the rocks, dissolving and carrying portions of these in solution to lower levels. Winter, with

* By request read before the Chicago Electric Club, October 20, 1888. Reported in the *Western Electrician.*

its irresistible frosts, widens the seams in the most obdurate rock formation, crumbles, and slowly — but surely—reduces them to a comminuted condition where they may again become sedimentary rock, once more to be subject to the will of the great plowman Nature, whose implement is the earthquake, whose furrows are the mountain ranges.

Within the earth, deep hidden from human ken, where the rock formation is of a nature to permit, huge caves are in progress of formation. Metallic bases combined with acids in the form of flakes or nodules absorb the infiltrating moisture from above, and the acid, having a greater affinity for the alkaline rock than for the metal, leaves the latter, and, uniting with the former, produces a new compound, which, being soluble in water, is carried away in the outgoing current. The metal, too, forming a new combination with the oxygen of the water, is similarly disposed of, and a cavity is formed in the bowels of the mountain. Here is the nucleus for a cave. In this way Mammoth Cave was formed; and Nature, tireless designer that she is, is still at work making additions and modern improvements in these, her magnificent underground palaces.

The transitions of water are familiar to you all. As rain it descends from the clouds, it penetrates the earth, evaporates, and is again precipitated upon the ground. It may assume the form of ice, or snow, or clouds, or steam, yet it is still water—the two combined elements of its existence are ever present. We may separate these by force, and the same force will reunite them. We may rarefy the fluid by heat, or condense it by the withdrawal of that force, but it remains water still. We have added nothing which did not exist before. We have taken away nothing. Thus we may ring all the vibratory changes on any subject in nature. We destroy nothing, we add nothing, and the conditions which wrought former changes and produced previous results will invariably repeat the phenomena in obedience to the unwavering fiat of vibratory law.

Our sulphate of copper batteries give us a fine exemplification of such changes from an electrical and chemical standpoint. Sulphate of copper, a combination of sulphuric acid and metal copper, is soluble in water. This forms one of the elements of our battery. Metallic zinc is used for the other. These are placed in water, and the connections being made, which render the circuit complete, the stored-up energy of the elements is released, the salt of copper is dissolved, and its component parts, sulphuric acid and metallic copper, are separated. The copper, restored to its metallic form, is deposited at the bottom of the jar. The sulphuric acid attacks and combines with the metallic zinc, producing sulphate of zinc, which is held in solution by the water. Now, when the action is continued until the elements are consumed, by evaporating the water and weighing the residuum, we will find just as much copper, and zinc, and acid as originally existed, but the combinations have been altered; and by still further manipulation we may separate the acid and the zinc, reducing the former to a liquid form and the latter to its metallic state, and recombine the acid and the copper so as to complete the cycle of vibration and erect a second battery, similar to the former, from the same elements.

Water in motion presents a fine illustration of one form of vibration. If we carefully observe a floating body, a chip, or a bird, on the dead swell of the sea, we shall find that the water motion does not carry the object away from its position, but merely compels it to rise and fall perpendicularly. A rope suspended from one extremity, when shaken, will give us the same wavy motion. The vibratory undulations will run from the one extremity to the other, until, overcome by gravity, they cease to be noticeable.

The vibrations of a large body of water, like the sea, are complex and of nearly every degree of amplitude. Not a breath of air passes over it; not a ray of light or heat penetrates it; not a sound is produced at the surface, within or below it, but creates a vibratory movement in the mass. The waves, the tides, the currents, the evaporation, the very color of the sea are as strictly amenable to vibratory law as are the strings of the violin or the pipes of a church organ.

Vegetable life furnishes another familiar illustration of vibratory law—this cycle of existence.

At first the seed, selecting and absorbing the proper nourishment from the surrounding soil, chemically changing the force thus released to its own use, it increases its dimensions, sending certain portions of its organism in search of farther food below the surface, and directing other members upward until its growth is finished, its mission ended, it first ceases to provide for the continuance of its species, then dies and decays and is returned to the soil and the air from whence it came. It has resolved into its primal elements and completed its vibratory cycle. Yet there are minor vibrations in constant motion during its entire life period, each complete in its own sphere of action; each to an extent a necessity, an element in the grand result.

Within the minute vessels, those veins and arteries that lead from the tiniest rootlet to the uttermost extreme of the highest leaf on the tree, what quantities of life blood have been carried up from the ground for its sustenance and refreshment. Thousands of hogsheads of water have been transported to the tops of the forest monarch during its years of growth, carrying with them the elements required for the food and growth of the wood, the bark, the leaves and the fruit, in addition to the forced contribution which the atmosphere has been compelled to contribute, and these elements have been appropriated, separated, assigned and assimilated, all in obedience to and by the aid of vibratory law.

The summer's growth, the winter's rest, the ripening and falling of the leaves and fruit, regular as are the seasons, are but so many annual vibrations in its period of existence.

Its various parts, too, are in constant motion, and whether we note the swaying trunk and bending limbs contending with the wintry gale, or the pendulum leaves gently waving in the summer breeze—vibrations in some degree or form are still the same ever-present accompaniment of its daily life.

As in the tree, so in the tiny blade of grass. Could we but invent some method of multiplying our hearing capacity in the same degree as the microscope has enlarged the field of human vision, every blade of grass, every clover stalk and daisy stem would roar with the laughing cataracts that rush through the little veins and arteries, and run the mimic mills to feed and paint their gaudy blossoms.

As in vegetable, so in animal existence. Birth, life, death, decay, follow each other to make up the vibration of physical existence with all animate nature. It is difficult to designate a function pertaining to animal life that is beyond the control of these laws. We breathe; respiration is vibratory. Our blood flows in pulsations. All nervous excitation, whatever the sense—sight, hearing, taste, touch, even thought, highest of all nervous sensations—all these are clearly vibratory in their action. Why, even our organs of locomotion are but vibratory appendages, like the fins of the fishes or the wings of the feathered world.

A clear conception of distance, beyond a limited range, is difficult of accomplishment. Even comparison with familiar areas or spaces, when applied to extended intervals, gives but unsatisfactory results. By day we behold the sun, which lights and warms the earth from a distance of nearly one hundred millions of miles away. By night we behold the lesser lights, the number of which, including the telescopic stars, is estimated at no less than seventy-five millions. Many, very many, of these are vastly superior in size to our own sun, which has over one million times the volume of our earth, yet, by reason of the great distance of these immense bodies, they appear to us as mere points of light.

The dog star, Sirius, the brightest star in the northern heavens, has the volume of sixty of our suns, yet such is its immense distance, about 100 millions of millions of miles away, its brilliancy is much inferior to that of the planet Venus, which is one-tenth smaller than the earth.

Now, to come back to the sun, the center of our solar system, we see it surrounded by a series of planets, each performing revolutionary vibrations around it, their cycles of movement varying with their varying masses and distances, and these again in many instances carrying with them secondary bodies each moving with uniformity the most precise, harmony the most complete, and with a grandeur awe-inspiring.

The planet on which we live has each day since its creation whirled in space, completing its diurnal revolution on its axis, and each year its annual movement about the sun, lighted and warmed by vibratory force from that great luminary, held in its position by vibratory law. And the sun, too, revolving upon its axis in about twenty-five and a half of our days, moves in an orbital track about some other sun, carrying with it the entire system of which it is the center; and this again is supposed to be a system dependent upon another, and another, until there is no conceivable limit.

It is beyond the grasp of the human mind, until infinity is explainable, until we are enabled to comprehend an existence which has neither beginning nor ending; and all these movements are amenable to gravity, which holds and controls these immense unnumbered masses in space; that sends them forward on their untiring journeys, over paths without tracks, with a uniformity and exactness to excite a feeling of wonder and admiration in the most skeptical human mind. Yet our own solar system has no mean or insignificant proportions when we consider the extended vibrations of comets in their annual revolutions round our sun.

One of these astronomical puzzles, of which the orbital elements were computed by competent authority, requires no less than 3,380 years to complete a single oscillation. When we remember that these wanderers are sometimes accompanied, during a portion of these orbital trips, by an attendant having a lineal measurement greater than the distance from the earth to the sun, we are struck dumb with astonishment and reverence at the immensity of the mechanical movements of these whirling pendulums of God's eternal clock.

Everywhere in nature there exists a substance of infinite elasticity and extreme tenuity, which surrounds the atoms and permeates every so-called solid. It fills all space throughout the universe. This substance is known as luminiferous ether. Vibrations from luminous bodies are taken up by it and transmitted by wave motion. Light is conveyed by it something similarly to the manner in which sound is conveyed by air waves, with, however, this marked difference: While sound waves move in one direction, those of light move at right angles to this—the former being, in scientific language, longitudinal, while the latter are transversal. The mechanical properties of this ether are rather those of a solid than of an air.

The vibrations of this extremely tenuous and elastic substance are, from its very nature, capable of inconceivably rapid movements and, from like causes, it is never at rest. The rays of the sun are brought to us at the rate of about 187,000 miles in a second. Sir John Herschel estimated that a cannon ball would require seventeen years to reach the sun, while light requires but eight minutes to traverse the same distance, and that while the swiftest bird would be nearly three weeks in flying around the world, light would make more than the entire distance for each stroke of its wing.

Light, pure and colorless, as it is given to us, is susceptible of divisibility. Nature does this for us in a most complete manner in the rainbow. Artificially this is done by the triangular prism, giving us the seven hues once known as the primary colors.

The principle which underlies this experiment is this: The different hues have different rates of vibration and different angles of refraction. The prism receives the ray of white light and, refracting it, breaks it up into its component parts, throwing the different colors at differing angles, and consequently at varying distances, upon the screen. Following up the result thus obtained led to the discovery of the spectroscope, by means of which the component parts of the blazing sun and the light from fixed stars are as perfectly analyzed and recognized as if manipulated in the laboratory of the chemist.

The solar spectrum shows peculiarities aside from colors which, like these, do not extend the entire length of the image on the screen. Beyond the rays which are there visible to the human eye, where all seems colorless and dark, at the one extreme of the spectrum rays powerful for chemical effect are found by the photographer and the chemist, while beyond the opposite or red extremity are found invisible rays of excessive heating power.

The ultra-violet rays, which to us are opaque, have, by late interesting experiments by Sir John Lubbock, proved to be less opaque to some classes of insects than even the yellow rays. We can have no conception of what the ants see in that portion of the spectrum.

Light vibrations, like those of heat and sound, may be deflected from their course. We see the sun, a star, or a candle by its own light, which reaches us in a right line from its source. Were it not for reflection, the light of the sun would be entirely shut off wherever a shadow now exists.

Echoes are illustrations of the reflections of sound vibrations. The long rolling thunder in a summer storm, succeeding a flash of lightning from one of nature's condensers, is but the reverberation of sound waves, hurled back and forth from cloud to cloud until silenced by absorption.

The tone of an engine bell, or the whistle of a train you are passing on a railway, rises rapidly to a higher pitch as the trains approach, and sinks again as they separate. The diminishing distance in the first instance increases the number of vibratory waves that strike the ear in a given time, while the receding trains diminish the number impinging upon the listener's ear during the same period, and the pitch of the tone, we know, depends upon its rate of vibration. The tone of a steam whistle is often varied by the engineer, who gradually opens and closes the valve, thus increasing the vibratory rate or decreasing it, sometimes carrying the whistle tone nearly or quite through an octave.

Vibrations may be absorbed. It is to this fact that we are indebted for the hues of all nature's beauty by field and hill, by glade and stream, where but for this provision all would be tiresomely similar and somber. This peculiarity of vibrations is made available by musicians in the use of the soft pedal of the piano and the mute on the cornet. In the acoustic telephone you all know how carefully the sound insulators must be adjusted to prevent the deadening of the vibrations, and so make even a tolerable success of it. Heat vibrations are readily disseminated and dissipated by absorption; vibratory waves moving rapidly or slowly according to the relative capacities of the source and the recipient.

Some recently published results of experiments by that eminent scientist, Chas. W. Siemens, with the electric light as an aid to vegetation, are interesting from this point of view.

These experiments extended over a period covering considerably more than a twelvemonth, both inside a greenhouse and in the open air. It soon became apparent that the open air plants, which received the light rays through the glass forming the frame of the lamp, were far more thrifty and in better general condition than those under cover which were exposed to a naked light.

The first attempted explanation of this fact was the assumption that the increased production of nitrogenous and carbonic compounds was in excess of the needs of the plants, and so acted destructively. All attempts, however, to remove the difficulty, by ventilation and otherwise, proved futile. Finally, a clear glass globe was placed around the light, and an almost marvelous change occurred in a single night. A sheet of glass was then placed so as to intercept the rays from one portion of the plant, while other parts of the same plant received the free rays. In twelve hours a distinct line of demarkation showed where the two sets of rays joined—and yet this difference was only the result of the interception of a thin sheet of clear, uncolored glass. So far as the eye could detect, no light was absorbed, nor was its color perceptibly changed, and yet a decided advantage was gained by passing the rays through this thin transparent medium.

Following up the hint thus arrived at, the learned investigator arranged the conservatory so as to submit different portions of this to the action of light transmitted through blue, red, yellow, and transparent glass and the uninterrupted rays direct from the lamp.

Under the clear glass the most satisfactory growth was induced. Next in the order of success came the yellow; the red light produced a spindling growth with sickly yellowish leaves, while the blue exaggerated these results; and the naked light, least successful of all, produced a dark and partly shriveled growth of foliage.

Now, in all these experiments, to the absorption of invisible rays, the arresting of the vibrations of some part of the beams of light from the electric arc, are due the curious and marked results obtained.

The air surrounding us is in constant vibration. Heat, light, sound, are constantly disturbing and varying its condition. The sound of my voice, originating in a muscular movement of the throat, is carried by the wave motion there communicated to the air, and thence to the uttermost parts of the room, with comparatively little effort. Yet, in doing this, I am effecting a sensible mechanical result on a gaseous body exerting a mechanical pressure of fifteen pounds to the square inch in every direction. These vibrations are sufficiently low in their rate of movement to produce an effect on the auditory nerve of the human ear.

Man has been classified by some satirist as a "two-legged boasting animal," and education has taught us to believe that the human race is superior, in every respect, to the so-called inferior creations of nature. We claim to be nearer, in every way, to the great Creator of the world, and highest in the scale of God's handiwork.

We are saved from mortification and exposure by the fact that the power of speech, that is, language which we can interpret, has been denied to the rest of the animal world. Could they but speak to us in our language, or could we but translate theirs, they would tell us of sound vibrations so rapid that the dull ear of humanity is incapable of receiving them.

The range of vibrations which are appreciable to the human ear is limited between sixteen and forty thousand per second. That is, a vibration which completes sixteen cycles in a second, or more rapidly, until it accomplishes forty thousand in the same period of time, is, save in anomalous instances, appreciable to the human ear; and these limits embrace the rates of vibrations of all appreciable sounds. Above or below these, to man, all is silence.

With an instrument similar to the siren, specially constructed for the purpose, Sir John Lubbock created the utmost consternation among the animals of a zoological collection and killed great numbers of insects, while no noise was heard by those standing near the instrument, nor was any disturbance experienced from its action. The rate of its vibrations required a more

delicate nerve organization than we are possessed of, to recognize their presence.

Perkins, the inventor of the steam gun, without recognizing the fact, arrived at the same result, namely, the production of rates of vibration above the capacity of the human ear, in the course of his experiments with steam in a high state of tension, from the standpoint of the phenomena of boiler explosions.

In a boiler of sufficient thickness and strength to secure perfect immunity from explosion, he drilled a hole not larger than a fine needle. He applied gradually increasing heat beneath this boiler until it reached the highest point attainable by the means at his command. As the heat increased, these phenomena presented themselves in the order named: At first, vapor exuded from the minute orifice, then white followed by blue steam, accompanied by hissing, succeeded by a low whistle. The sound increased in both force and shrillness, rising finally to an almost deafening shriek which the experimenter says could be heard a mile. Then the sound grew gradually fainter until silence ensued, the quantity of visible steam decreasing until neither sound nor steam was appreciable, but the circumference of the orifice became hotter, and eventually assumed a bright cherry-red color. The rate of audible vibrations had been passed, and some of these were now being reconverted into heat in their passage. The source of heat was now removed and the various results were again arrived at, but in an inverted order of succession.

Had Perkins been investigating vibratory law, instead of boiler explosions, he would doubtless have seized upon these capital illustrations of the conservation of energy.

His theory of the silence and the non-issuance of steam at the point of greatest pressure was, that the heat had, by expanding the steam particles, so enlarged these that they were unable to pass the orifice, which had become partially closed by the expansion of the metal surrounding it.

The human eye compares no better with those of a lower animal creation. The birds, many of them, and especially those of the family to which eagles, hawks, and vultures belong, are furnished with telescopic eyes, by which variations of distance—to what extent we know not, but we do know they are great—are almost instantaneously compensated for by focal changes in the eye.

I have seen a hawk dive from the top of a high tree and seize a mouse upon the ground quite near me, before the latter could reach a hiding place ten feet from its nest which I had just overturned; and yet from that bird's lookout to me was a distance so great, I much doubt if I could have seen a squirrel to recognize it with certainty.

Some one has said, in substance, of the human eye, that it answered very well for want of a better, but that an optician who would call attention to a specimen of his work which combined so many imperfections as the best human eye always includes, would lose rather than gain by his advertisement.

The "eyes of science," as Proctor has so aptly designated those optical appliances, the microscope, the telescope, the camera, and others, are far more perfect in many regards than those combinations of lenses nature has furnished to humanity. The human eye is impressed instantly, but it ordinarily requires about one-sixth of a second to lose the perfect impression of any object, and this persistence of vision blurs by interference the next subsequent impression.

A meteor in the sky is to us, in its rapid movements, a luminous line, while we know that its form is globular. A sky rocket produces much the same impression, and a fire wheel, after its pyrotechnic fires are extinct, still shows a ring of fire while its motion is dying down if the case has but a spark upon it. Sparks from burning charcoal or from a chimney, are streaks of fire; and a discharge from a Holtz machine, like that from one of nature's larger accumulators, is ever a streak of lightning. The spokes of a carriage wheel are blended in rapid motion and the wheel assumes the appearance of a disk, while the action of a horse, at a rapid pace, is never well defined by the retina, except where an instantaneous illumination is followed by absolute darkness. Yet the camera of the photographer is competent to catch and preserve the attitude of the swiftest moving animal. Perfect representations of the fleetest racers have been thus secured with a plate exposure of such short duration that the entire animal has been pictured in the air, not one foot touching the ground.

Photographs of the sun have latterly been taken so nearly instantaneously as to show details impossible of procurement by any other method, and which of course had never been known before.

And the eye of science is equally superior to the human organ in other important regards. Without wearying, without even winking, it will hold its unflinching gaze, as in the case of photographing nebulæ, where two or three hours are required to fix an impression of these faint bodies; and this, too, while most ingenious apparatus is required in combination with it to compensate its visual direction for the complicated movements of the earth during the long exposure.

In various portions of the world are found caves, the waters of which are inhabited by sightless fish—creatures possessed of only rudimentary eyes; in other words, so imperfect is their visual organism that, to all intents and purposes, they are totally blind. The light of day never reaches them, yet they are capable of finding their proper food, escaping from danger, hiding or fleeing when pursued; in short, accomplishing their fish destiny in much the same manner and apparently with as much success as their more fortunate and higher developed cousins in the waters above ground.

Some experiments made with specimens of these fish showed interesting results. They were confined in an aquarium in which was placed a considerable quantity of ragged rock, selected and arranged to form the best possible dark hiding places, and thus adapt their forced existence, as nearly as might be, to their natural requirements.

It was noticed that in all their movements they passed freely back and forth, around and among the rocks, without hesitation, even when suddenly startled by concussions, noises, etc., and they were found to be extremely sensitive to the least disturbance. Touching the water never so lightly with a broom straw caused them to hide at once.

A fish of a different variety, but possessed of perfect vision, was procured and placed in the aquarium, when immediately a new series of phenomena presented themselves. As the strange fish struck the water, the poor blind creatures, instead of shrinking with fear and seeking a hiding place, at once assumed the offensive and gave chase to the intruder, who fled, evidently conscious of danger. It practiced all the knowledge it possessed in doubling and turning the angles and threading the intricate passages among the rocks, and was closely followed until overtaken and destroyed by its sightless enemy. In all this chase the track was never lost, the threatening projections of rock were evaded as readily by the pursuers as by the pursued, and no evidence was adduced to indicate that the one had not visual powers as perfect as the other.

Now, vibration, in some form, guided these sightless creatures in the pursuit of the intruder. Whether those pertaining to smell, or feeling, or sound, we know not, we can only conjecture.

A blind man, one who from birth, or for many years, has been deprived of sight, is to some extent compensated for his lack of vision by increased sensitiveness of other faculties; but these never reach the perfection shown in the experiment mentioned.

The brain in the higher developed types of animate nature we consider the seat of the mind, of thought, of that will power which controls, through a system of vibratory nerve telegraph, all physical action. Physiologists tell us that at this center of life action the record is made of all outward impressions.

In telephonic parlance, it is a sort of central office, whence all responses are made, and to which all calls are sent. These delicate lines are no more wonderful than varied in their capacities and adaptations to rates of vibratory action, each within its own range or sphere.

The auditory nerve, divided into some three thousand harp strings, is incapable of receiving impressions from finer vibrations than those pertaining to sound. The delicate organism of the inner ear may be injured so that ordinary audition is impossible, yet, if the little harp be intact, the proper rates of vibration may be communicated to and received by it through other nerves which lie in the immediate neighborhood. A deaf person may often be made to hear the twanging of a stretched cord or wire, one extremity of which is held in the teeth. The sound is communicated through the bones of the head to the inner ear. The audiphone held to the face or any fleshy part of the person will give no result; and it is valueless to those whose teeth are "marvels of art." Nor will the audiphone accept the lower jaw as even a passing good substitute, for the mechanical separation of this from the head bones interposes at the joint an imperfect conductor.

Pungent odors often produce marked effect on the pneumogastric nerves, while a derangement of these latter may sometimes produce an effect upon the olfactories. In all these cases the vibratory effects are secondary rather than primary in their nature and power.

In the lower animal organisms, though no brain, as such, is found, there still exists, for all the requirements of these less perfect creations, a system of mental action by which all needs are provided for. Fear, hunger, the baser passions, maternal instincts, etc., are more or less perfectly developed.

Still farther down the scale we find in vegetable life action which so closely approaches to that of scientific life as almost to obliterate the dividing line between the two. An acorn, starting on its life journey, finds itself opposed by unpropitious circumstances. The soil is unfavorable—a rock impedes its progress. The weakly little shoot, deterred by nothing, sends out its tiny rootlets, downward or laterally, as the case requires, but always in the right direction, in search of the proper nourishment. The plant root is a faithful, honest commissary. Prevailing winds threaten its overthrow when the little oak has attained to respectable dimensions, and now it displays the talent of its engineer, throwing out strong, bracing roots, yet always in the proper direction, to prevent the threatened disaster.

See the fruit-bearing tree in the blooming season. Could every flower there become a perfect fruit, death would inevitably ensue from the ill-proportioned weight on the boughs. What is the remedy? The tree, as if it reasoned with itself, seems to say: "I have provided for accidents which have not befallen me and I have now a greater call upon my energies than is safe for my health and the good of my offspring." It dooms certain of the germs to destruction. There is no law against infanticide in nature, and the condemned, deprived of the requisite nourishment, wither and fall. Again and again, during the season, does the tree enact the several roles of accuser, judge, and executioner, until it has decided what shall finally remain, and then the work of growth and ripening goes on swimmingly. It is true there are occasional mistakes made, more being undertaken than can be carried to a successful conclusion, or less than an average number of germs retained. In the former case the rule of the greatest good to the greatest number is adopted, while in the latter everything is done for the few; quality and perfection being the apology for meager quantity.

Trees make mistakes as well as men, but trees have no brains.

Minute differences in vibratory rates are capable of producing most striking results. In musical tones, doubling the rate of vibration invariably raises the tone one octave, and every increase or decrease of the vibratory rate of a tone changes its pitch proportionately. But the same absolute pitch sounded upon two different instruments produces entirely distinct impressions upon the ear. Why? Because of the overtones, the combinations of minor vibrations, which are ever the accompaniment of any tone. These minor vibrations are combined in different proportions in different sound sources. A silver flute has not the same tone as one of wood, and the clarionet is unlike the violin in the quality of its tone. This quality of tone is almost endless in the variety which it permits in music. But material has not alone the control of this peculiarity of tone quality. Form has much influence. It lies at the bottom of those differences in the human voice by which we are enabled to select musical or unmusical vocal efforts. By the quality of a voice we may recognize an acquaintance in the dark, even after years of separation.

A careful study of the quality of the human voice is as necessary in the selection of a vocal band as is the quality combination in an aggregation of instrumental musicians. The fewer the number, too, the more apparent will be the want of that finer harmony, the pleasing effect of properly selected quality in the voices or instruments, if this study is neglected. Understand, I do not speak now of the ability to correctly reproduce every note, but a capacity to make these notes so produced blend harmoniously as a whole.

The finest singer, in advancing years, may, while retaining all the accomplished knowledge which education and practice have wrought, be very unmusical in vocal effort by reason of a changed quality of voice.

Another marked result in music is chargeable to these overtones or sub-vibrations. Musical instruments are imperfect in their construction. Theoretically we assume that the scale is made up of a certain number of steps or tones or half steps and half tones, and that certain differences in the number of vibrations will produce a note or a half note above or below a given tone. But you who have been compelled to listen to a piano or organ tuner know that he is a longer time at his work than would seem necessary were this the fact. Practically, there are a certain number of vibrations which he is compelled to distribute throughout the entire length of the keyboard, the result of which is that the tone steps are not of equal length, nor is the same number of vibrations added or deducted to produce a half step. It is this difference in the intervals which assigns bold, martial music to the sharp keys, while plaintive, gentler strains are found better adapted to the flat keys. Any pianist who will play the Star-Spangled Banner, for instance, alternately in two sharps and four flats will, I think, readily comprehend this difference. We are thus enabled to accomplish far greater variety in music than would be attainable were these distances between notes uniform in extent.

There are minute vibrations which result in changing the molecular distances of fluids, forcing these asunder and causing evaporation. Noxious smells are created in a somewhat similar manner, as well as perfumes, and the distinctive odors of animals and insects and by which they recognize and trace each other.

It is related of a dog, who had long been the constant companion of a horse, that, being separated from the latter animal for a time, he accidentally crossed his track, and recognizing the scent, immediately followed and overtook his old friend.

The foxhound, trained for hunting, will only follow the trail of the fox under any circumstances. I have been told by an old hunter that these animals have been known to follow a fox track in a line parallel to it, many rods away, with a favorable wind blowing toward them, for long distances. This delicate appreciation of distance by the strength of the scent is something of which humanity can have no adequate conception until we are educated up to the olfactory capacity of a foxhound.

Vibratory sensation is capable of development. Practice in the microscopist gives him a power of vision which the uninitiated little dreams of. The piano tuner will discover an inharmonious element in a musical chord which to another would be utterly unappreciable. The tea taster will detect a shade of flavor or value between samples which to the uneducated would be precisely similar. The physician readily recognizes the odors of diseases, in some instances, when these are sufficiently concentrated; but when the vibratory antagonism of the molecules of these have separated them until there is no more than the highest homeopathic attenuation of the atmosphere, there may still remain sufficient of both quantity and intensity to reproduce the parent disease.

I may be chimerical, but I believe the day will come in the not distant future when the ingenuity of man, through the patient plodding of some hard worker in the still rich fields of vibratory law, will mark the rates of perfumes and odors, and tabulate the vibrations of disease germs as perfectly as we now count the vibrations of sound and light. How this may be accomplished I know not; it lies in the dark future, but the discovery and its application will be no more wonderful than the development of the spectroscope which tells us of the fires in the sun, which names the metals in a glowing fire a hundred millions of miles away in space, which names to us in language that any scientist in any land may read—in nature's own tongue—the fuel in glowing suns sixty times larger than our own, by analyzing to-day a ray of light that left its source years ago, and which tells us whether different suns are traveling toward or retreating from our own solar system.

Look at the record of the past hundred years, and noting the progress of science, ask yourself if this is to-day more distant than was the telegraph, the telephone, the induction coil, or the electric light, a century ago.

One curious thought in all this study of vibratory law obtrudes itself upon our attention, and is worthy of note here. Nowhere has man invented a mechanical motion which is not more or less directly a reproduction of one of nature's own. Reciprocating motion? It is found in the molecular movements of particles. Rotary motions have their prototypes in winds, in the movements of vapors, in the orbits of the heavenly bodies, and in their diurnal revolutions.

The swinging bough and the waving grain are repeated in the pendulum—the true type of all excursionary motion. The Leyden jar, the condenser, and the induction coil are thunder clouds in miniature, and the electric light is but a continuous stream of lightning, while the Geissler tube contains but a pocket sample of Aurora Borealis, put up air tight for home consumption.

Vibratory law lies at the very bottom of all vegetable and animal life. To it we are indebted for all that is beautiful in art and in nature. It gives us all our magnetic and electrical action. It actuates our telegraphs and our telephones, the fire alarm and the electric light. Our batteries would be powerless without it. Nay, more; without these minute movements, which pervade the entire universe, there would be neither heat, nor light, nor color. The stars would cease to shine, and the sun would be a blank, invisible. The earth would refuse to move; all sound would cease; darkness, and death, and chaos would instantly succeed to the present beautiful creation.

To calculate number of shingles for a roof, ascertain number of square feet and multiply by 9 if 4 inches to weather, 8 for 4½ inches, and 7 1-5 if 5 inches are exposed. The length of rafter of one third pitch is equal to three fifths of width of building, adding projection.

RETOUCHING NEGATIVES.

MR. W. H. DEBENHAM, in the *Photographic News*, gives the following practical directions:

The abrading process with resin or cuttle fish powder may be employed either upon the gelatine film itself or upon the ordinary negative varnish; the latter plan is, however, the more usual. If the film itself is rubbed, care must be taken not to rub so much as to remove any appreciable amount of the deposit forming the image; and with some films containing a small proportion of gelatine to the bromide of silver this may not be easy to avoid. The mere fact of roughening the surface imparts a little additional opacity to the negative, so that shadows will not print through quite so clear, and too dense high lights will be rather aggravated than otherwise. With resin powder this opacity almost, if not entirely, disappears on warming, and with either powder used upon the film before varnishing, it disappears upon the application of the varnish. In some cases, however, the added density is an advantage. In a thin and under-exposed negative the flesh in shadow will print rather lighter from the roughening treatment, something like the effect which is obtained by the plan often adopted in such a case of putting a thin wash of color on the back of the plate. The extra density conferred by roughening will be seen very disadvantageously if the rubbing be continued on to the background, when a patch of light will be seen extending as far as the roughening process has gone. Still another method of using the resin powder is to rub the plate as already described, and then to warm it before retouching. As soon as cold it is ready for the work, which it will take in a very satisfactory manner.

Although the rubbing method has been very much superseded by the use of such a medium as will presently be described, it is really a good method, and excellent work has been done in this way. For inexperienced hands it is especially to be recommended, as there is less danger than when a medium is used of making too dark a stroke.

We now come to the plan which is in most general use at the present time for preparing the surface of a negative to receive the work of the pencil, the application to the film of a resinous or gummy solution called a medium. Several formulæ for the preparation of such a medium have been published, of which some are excellent, while others give so much solvent in proportion to the gum as to make too thin a solution. Some, too, contain an unnecessary complication in the mixture of gums. The writer remembers to have seen a receipt which was thought very highly of, as being that of a very skillful worker, and no doubt the medium made according to it was good; but there was, in addition to several other gums, one which is insoluble in the liquid (turpentine), while of the active ingredients one was resin and another Venice turpentine. As the latter substance is now generally prepared by the chemist by mixing resin and turpentine together, the unnecessary complication of the formula is obvious.

One of the first formulæ given for making a retouching medium consisted of balsam of copaiba thinned with turpentine. Two parts of turpentine to one of the balsam make a solution that works very satisfactorily. It is slower in drying than some other mediums, and on this account is perhaps not quite so suitable when the negative has to be retouched immediately that it is prepared, and put out to print directly the work is finished. On the other hand, if the work upon the negative is not finished at once, but may have to be put aside till the next day for completion, the copaiba medium is very suitable, as the pencil will still take very well, which is not the case with all mediums. Canada balsam may also be used, but will require rather more turpentine—say four parts of the latter to one of the balsam.

Of the gums that have been used for making medium, common resin and gum dammar have probably been the most largely employed. The following formula is exceedingly simple, and gives a medium which in the experience of the writer and others works thoroughly well when the negative is to be retouched within an hour or so, and not put away for a day or more, after which time, although work may be put upon it, it will be with some difficulty:

Yellow resin	1 ounce
Turpentine	5 ounces

Dissolve and filter.

Another formula—

Gum dammar	1 ounce
Turpentine	5 ounces

A convenient way of dissolving gums is to make a little bag of coarse muslin to contain the gum, and let it hang in the vessel containing the solvent, just below the surface. For making a pint or so of medium, a pickle bottle will be suitable, and the bag may be long enough for the top of it to be just nipped and retained in position by the cork. For smaller quantities a wide-mouthed bottle of the pomade kind answers very well.

The medium, if containing gum, should be filtered through paper. With balsam and turpentine alone this may not be necessary.

A very good medium for general use may be made as follows:

Gum dammar	3 ounces
Turpentine	18 "

Dissolve and filter, and add—

Balsam of copaiba	1 ounce

Another very similar in use:

Yellow resin	1 ounce
Turpentine	18 ounces

Dissolve, filter, and, as before, add—

Balsam of copaiba	1 ounce

A medium that comes to about the same thing as the resin medium, but may be more quickly mixed, is—

Venice turpentine	1 ounce
Turpentine	2 ounces

If slower drying is preferred, part of the Venice turpentine, say one-third, may be substituted by copaiba balsam.

Those who do not care to be at the trouble of preparing the medium will find several in the market which closely resemble in working those made by one or other of the foregoing formulæ.

Any of the mediums given may be used either upon the gelatin film itself or on the varnish. A small quantity is applied with a clean soft rag, and rubbed until the coating is even. Too much must not be removed in the rubbing, especially if the negative has been varnished, or the pencil will not take properly. The negative is then generally left for a few minutes for the turpentine to evaporate, and the medium to become hard and dry; but for some purposes, as will be mentioned farther on, the writer prefers, especially if it be a quick-drying medium—*i. e.*, one without balsam—to commence the work at once.

TONING BATH FOR IMPARTING COLD TONES TO PRINTS ON GELATINO-CHLORIDE OF SILVER PAPER.

THE *Progres Photographique* gives the following formula for a toning bath imparting cold tones to copies upon gelatino-chloride of silver paper:

Chloride of gold	2 parts.
Sulpho-cyanide of ammonia	20 "
Sodium phosphate	20 "
Water	92 "

For warm tones the sodium phosphate is replaced by sodium acetate.

Fix for twenty minutes in a 20 per cent. solution of hyposulphite of soda; the prints are then placed for six minutes in a chloride of sodium bath of suitable composition, and afterward washed for three or four hours in running water, and finally hardened by treatment with a 20 per cent. solution of chrome alum. Dry at an ordinary temperature.—*Br. Jour. of Photo.*

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